ES&H manual

Environment, Safety, and Health

Volume II

Part 22: Emergencies/Earthquakes/Fire

Document 22.4
Earthquakes

Recommended for approval by the ES&H Working Group

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New document or new requirements

Approval date: July 25, 2000
Editorial Update: March 3, 2004

This work performed under the auspices of the U.S. Department of Energy by University of California Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

22.4

Earthquakes*

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Earthquakes

1.0 Introduction

This document contains requirements and guidelines for preparing for earthquakes that may occur at LLNL's Livermore site, Site 300, and NTS. The principal objectives of the LLNL with respect to earthquakes are to reduce the risks of personal injury, property damage, and programmatic interruption. No other type of credible disaster caused by a natural phenomena hazard (NPH) is likely to involve the entire Laboratory and the entire surrounding community. Hazard reduction is achieved by complying with building codes, applying good engineering and housekeeping practices, and providing training programs required for managers and workers. Although LLNL's Livermore site and Site 300 are somewhat removed from major earthquake faults in California, they are located near several active, shorter faults. Four such faults, namely Tesla, Verona, Las Positas, and Greenville, are not capable of producing an earthquake felt over large areas of California. However, they can produce short-duration tremors with locally strong ground motion and high accelerations. During earthquakes on the Greenville Fault in 1980 (magnitude around 6 on the Richter scale), peak ground acceleration at the Livermore site was about 0.3 g, where g is the acceleration of gravity. Two fault zones—Corral Hollow and Carnegie—have been identified near Site 300, but have shown no evidence of seismic activity within the last 10,000 years. The Greenville fault exhibits a greater hazard to Site 300 than these inactive fault zones.

Historical records indicate that approximately once every 20 years, the LLNL site is subject to an earthquake that can at least knock books off shelves and overturn or move furniture. No active faults are known to underlie the site, and there is no historical record of surface rupturing or faulting at the site. Flooding resulting from seismic events would not occur at LLNL from a failure of the Del Valle Reservoir dam, from loss of water from the Patterson Reservoir, or from a break in the South Bay Aqueduct near LLNL.

The major faults—San Andreas, Hayward, and to a lesser extent, Calaveras—have a very low probability of causing ground motion at LLNL that is as strong as that from the shorter faults, but the tremors can last longer. The Loma Prieta earthquake of October 1989 on the San Andreas Fault (magnitude around 7) registered a peak ground acceleration at LLNL's Livermore site of approximately 0.1 g.

2.0 Pre-Earthquake Planning

Laboratory personnel can reduce the risks of injury or damage by the following actions:

- Survey your work area for overhead objects that may fall and strike you or others. Remove the objects, lower them, or have them properly anchored or secured.
- Secure bookcases, racks, and other equipment more than 5 ft tall.
- Do not hang heavy items (e.g., potted plants) from light fixtures or suspended ceilings.
- Store chemicals in cabinets securely fastened to floors or walls that have mechanical latches (magnetic types are not effective) and on shelves reinforced with earthquake strips, lips, rods, or wires.
- Do not store incompatible materials together that could mix if containers break.
- Keep passageways clear of any item that could overturn or collapse and block an exit during a temblor.
- Know where fire extinguishers and emergency supplies are kept.

Contact the Hazards Mitigation Center (HMC), a multi-directorate center available to provide NPH support including evaluation of the seismic resistivity of equipment and experimental apparatus. The HMC is located at LLNL in Trailer 1403. The HMC can be visited at the following Internet address:

http://www-ep.es.llnl.gov/www-ep/ghp.html

Contact the Safety, Education and Training Section of the Hazards Control Department to request training in earthquake preparedness.

Laboratory personnel shall also be familiar with the Disaster Self-Help Plan in their work area. Refer to Document 22.1, "Emergency Management," in the *ES&H Manual*.

It is recommended that each worker also prepare a family emergency plan.

3.0 During an Earthquake

Remain calm during an earthquake, and think through the consequences of any action you take. Try to calm and reassure others. Remember the simple rule: duck, cover, and hold on. You can reduce the risk of injury by the following actions:

- When indoors, watch for falling plaster, bricks, light fixtures, and other objects. Pay particular attention to bookcases and filing cabinets. Stay away from windows. If in danger, duck. Get under or near a sturdy table or desk in a corner away from windows, or stand in a strong-framed doorway. Protect (cover) yourself from injury, especially your head and neck. Remain covered until the shaking stops. Hold on to whatever you have chosen for protection so that you are not injured by the object itself. If the object you are holding moves, move with it. Encourage others to follow your example. It is usually best not to run outside due to possible fallen electrical wires, and other falling hazards.
- In a high-rise office building, get under a desk or move against an interior wall, and protect your head with your arms. Do not dash for exits. Stairways may be broken or jammed with people. Do not use elevators because they may fail.
- In a crowded area, do not rush for a doorway; others may have the same idea. If you need to leave the building, choose your exit as carefully as possible.
- When outside, avoid high buildings, walls, power poles, and other objects that could fall. Do not run through streets. If possible, move to an open area away from all hazards. Move away from downed electrical wires and poles.
- If on a sidewalk near buildings, duck into a doorway to protect yourself from falling bricks, glass, plaster, and other debris.
- If in a vehicle, slow down carefully, pull over to the side of the road, and stop in the safest place available. Avoid overpasses, bridges, underpasses, power lines, and other hazards. Stay inside the vehicle until the shaking is over. Turn on your radio to get information (the LLNL Radio Station is 1610 AM).
- If in a wheelchair, stay in it. Move to cover, if possible, lock your wheels, and protect your head with your arms.
- If in an auditorium, stay in your seat and protect your head with your arms. Do not try to leave until the shaking is over. Then leave in a calm, orderly manner.

4.0 After an Earthquake

After the shaking has stopped, proceed in an orderly manner to the designated assembly point for your area unless directed otherwise. The Assembly Point leader will coordinate an accounting of personnel and provide instructions. If you are leaving a building, be alert for persons who may be trapped or injured, and for fire, chemical spills, or structural damage. Report such information to the Assembly Point leader.

Check your fellow workers for injuries. Do not attempt to move seriously injured persons unless they are in immediate danger of further injury. Administer first aid only if correct emergency procedures are known and they do not endanger yourself or the victim. For emergency assistance, call 911. If calling from a cellular telephone, dial 447-6880 for onsite emergencies. In addition, take the following actions:

- Check for fires or fire hazards, particularly in chemical storage areas.
- Check utility lines and equipment for damage. If there are gas leaks, shut off the main gas valve. Shut off electrical power to damaged equipment. Do not use matches, lighters, or open-flame appliances until you are sure no gas leaks exist. Do not operate electrical switches or appliances if gas leaks are suspected; such items may create sparks that could ignite gas from broken lines.
- Do not touch downed power lines or objects that are touching downed wires.
- Clean up spilled chemicals and other potentially harmful materials as soon as possible. Follow appropriate procedures for spill clean up.
- Check to see that water or sewer lines are intact before use.
- If power is off, check freezers and refrigerators for chemicals and other heat-sensitive materials, leave doors closed.
- Do not use the telephone unless you have an emergency. The telephone system, even after a minor earthquake, becomes so overloaded with calls that people with emergencies have difficulty placing calls. Wait at least one-half hour before calling home or elsewhere.
- Follow instructions that may be given over the emergency public-address system. If you are told to evacuate the building, go to the designated assembly point for your area unless directed otherwise.
- Supervisors shall take a count of their personnel to determine if any are missing.
- Sweep teams or facility points of contact shall check their facilities and report any emergencies to the Assembly Point Leader.

In the event of a major earthquake in the Bay Area, LLNL will attempt to advise workers about road conditions and general information over the emergency public-address system and Laboratory Radio 1610 AM.

5.0 Seismic Design Criteria for Structures

DOE O 420.1 requires that all new construction shall, at a minimum, conform to the Model Building Codes applicable for the state or region, supplemented with additional safety requirements associated with the hazards in the facility in a graded manner. DOE O 420.1, paragraph 4.4, "Natural Phenomena Hazards Mitigation," assures that all DOE facilities are designed, constructed, and operated so that the general public, workers, and the environment are protected from the impact of NPHs. The provisions apply to all NPHs, such as earthquakes, strong winds, flooding, and lightning. For hazardous facilities, safety analyses shall include the ability of structures, systems, and components (SSCs) and personnel to perform their intended safety functions under the effects of natural phenomena. SSCs shall be designed, constructed, and operated to withstand the effects of earthquakes as necessary to ensure the protection of life safety for occupants, the confinement of hazardous material, the operation of essential facilities, and the protection of government property. The design process shall consider potential damage and failure of SSCs due to both direct and indirect natural phenomena effects, including common cause effects and interactions from failures of other SSCs.

Two Executive Orders (EOs) are also applicable to seismic safety. The first is EO 12699, "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction," which requires federal agencies to develop and promulgate specifications, building standards, design criteria, and construction practices to achieve appropriate earthquake resistance. The second is EO 12941, "Seismic Safety of Existing Federally Owned or Leased Buildings," which requires adoption of minimum standards for assessing the seismic safety of buildings and in mitigating unacceptable seismic risks in those buildings. It also sets forth a timetable for developing an inventory of government buildings and the costs for mitigating unacceptable seismic risks in those buildings. DOE O 420.1 implements these requirements, establishes a requirement to review the natural phenomena hazards assessment for existing sites at least every 10 years, and requires an update of information if there are new findings relative to the seismic environment.

The current seismic design criteria for modifying existing buildings, and for all new building construction at LLNL, exceed the requirements set forth in DOE O 420.1, Chg. 2. Furthermore, LLNL follows the seismic design criteria in the Uniform Building Code (UBC). For critical buildings (where there is a potential for the release of significant quantities of radioactive or toxic materials), the more stringent criteria required are listed in DOE Order 420.1, Chg. 2, and DOE orders and standards referenced therein.

The following DOE Standards have been adopted to meet DOE requirements: (Available from web site.)

- DOE-STD-1020-94 (C1), "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities."
- DOE-STD-1021-93 (C1), "Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components."
- DOE-STD-1022-94 (C1), "Natural Phenomena Hazards Characterization Criteria."
- DOE-STD-1023-95 (C1), "Natural Phenomena Hazards Assessment Criteria."
- DOE-STD-1027-92 (C1), "Hazard Categorization and Accident Analysis Techniques for compliance with DOE O 5480.23, Nuclear Safety Analysis Reports."

This series of standards establishes the means and methods for evaluating the seismic risk at LLNL. DOE-STD-1020-94 presents an approach using the Performance Categories (PCs) established in the NPH Implementation Guide of DOE O 420.1. and discussed in DOE-STD 1021-93. PCs and performance goals apply to all facilities, from conventional buildings to facilities with hazardous materials or operations. The standard also discusses probabilistic performance goals and annual probabilities of exceedance for seismic events. DOE-STD 1022-94 and DOE-STD-1023-95 set forth assessment criteria for determining the design basis earthquake ground motion.

Other DOE orders including DOE O 5480.23, "Nuclear Safety Analysis Reports," require that DOE nuclear facilities undergo safety analyses and evaluation for all plant operating, accident, and extreme environmental conditions including earthquakes.

The LLNL has established seismic design criteria for use in evaluation and design of all of its facilities. The criteria have been reviewed and found to be consistent with the seismic hazard level postulated for the Livermore site. Probabilistic, site-specific, seismic hazard curves were generated for Livermore Sites 200/300, and the Nevada Test Site (NTS), and ground motions were determined for use in the design and evaluation of SSCs (Geomatrix, 1991).

Table 1 shows the currently accepted values for horizontal and vertical ground accelerations to be used for the design of facilities and equipment at Livermore Sites 200/300 and at the NTS. Table 1 assumes horizontal and vertical acceleration are equal, and the use of standard spectral shapes. Refer to the *ME Design Safety Standards Manual*, Section 5.2, "Seismic and Wind Design Criteria," for additional details and examples. (Available from web site.)

6.0 Disaster Plan For Earthquakes

Effective disaster preparedness for a major earthquake requires a separate plan. No other type of credible disaster is likely to involve the entire Laboratory and the entire surrounding community.

Table 1. Peak Horizontal and Vertical Ground Accelerations used for design at LLNL and the NTS.

Performance category[a]	Hazard return period (years)	Design peak ground acceleration (g) at Site 200/300	Design peak ground acceleration (g) at NTS
PC-1	500	0.47	0.3
PC-2 and PC-3	1000	0.57	0.3
PC-4	5000	0.82	0.46

[a] See DOE-STD-1021-93, Chg. 1, for a discussion of performance categories.

Outside help may not be available for several hours; therefore, the LLNL *Emergency Plan* (1999) calls for the Laboratory to be self-sufficient during this time. The Lab-wide Plan has provisions for handling multiple casualties, multiple fires, multiple spills of radioactive and other hazardous materials, and multiple security problems. Each directorate is also required to have a Self-Help Plan to provide for assembly, control, and assistance to workers and visitors in their area in the event of an emergency. The LLNL *Emergency Plan* and Document 22.1 describe the elements of a Self-Help Plan.

Exercises related to Self-Help Plans are performed periodically and annually.

7.0 LLNL Seismic Safety Standards

Numerous federal, state, and local codes are concerned with the structural integrity of buildings during earthquakes. Occupational Safety and Health Administration (OSHA) standards for storage, electrical safety, machinery, and other items can be used for nonstructural seismic safety. However, only a few mandatory standards, such as California "Elevator Safety Orders," deal with nonstructural items that have been shown to be of importance in recent California earthquakes. Local municipalities have adopted codes and standards for certain elements, such as required securing of gas cylinders, secondary containment of hazardous materials, use of gas cabinets for highly toxic gases, and automatic shut-off valves for toxic, flammable, or reactive gases.

The LLNL seismic safety standards listed below were developed from local experience and after review of experiences by others resulting from many earthquakes around California and the rest of the world. They were also generated from other recommended standards.

For details on current seismic criteria for equipment tie-down, see the *ME Design Safety Standards Manual*, which is available from the Mechanical Engineering Department office. Refer also to Plant Engineering's LLNL Facilities Standard PEL-S-13082 "Seismic Tiedown for Shelving and Cabinets" and other LLNL Facilities Specification documents available from the Plant Engineering Standards and Documentation Group.

7.1 Storage (General)

- All bookcases, filing cabinets, racks, shelves, and storage cabinets 5 feet tall or more shall be secured to walls or floors, or to other secured items in accordance with the LLNL standards contained in LLNL Facilities Standard, PEL-S-13082. Four-foot-tall bookcases with legs (total height of 4.5 feet) present a special problem because the legs may collapse during an earthquake. The legs should be removed or the bookcase secured to prevent collapse or overturning.
- Shelves 5 feet (1.5 m) high or taller shall have material restraints to prevent objects from falling and possibly injuring nearby personnel. Restraints shall consist of chains, bungee cords, or other methods as required by individual circumstances.
- Bookcases, filing cabinets, shelves, and storage cabinets shall not be stacked on top of each other, or on top of desks, tables, etc., without being properly secured.
- Refrigerators and other similar cabinets over 5 feet in height, which could roll and/or fall and injure personnel, or which could roll and/or fall and block an exit or passageway, shall be secured against seismic movement. The application of this guidance is on a case-by-case basis and should be determined by your Industrial Safety Engineer.
- Wheeled equipment, such as storage cabinets, gas cylinder carts, tables, and similar items, shall be designed such that the wheels or wheel assembly cannot unintentionally separate from the equipment or cabinet. They shall be restrained from falling or rolling into required exit ways.
- Materials stored in building egress areas (e.g., corridors, stairways, and lobbies) shall be approved by the Fire Marshal and shall be secured so as not to move or fall into required exit ways.

- Valuable materials sensitive to shock damage, such as laboratory instruments and expensive glassware, shall be stored in latched cabinets or otherwise secured against falling.
- Desktop computers, monitors, printers, fax machines, etc., should be restrained or located such that they will not fall or overturn. Methods for securing these devices include the use of industrial grades of hook-and-loop (Velcro) type products, webbing straps, blocking, and locating them on floors where practicable.

7.2 Storage (Hazardous Materials)

- Hazardous material (e.g., radioactive, toxic, reactive, or carcinogenic) should be stored in unbreakable or coated containers whenever possible.
- Hazardous material stored in glass or other easily breakable containers shall be protected from damage during earthquakes.
- Incompatible materials shall be stored in such a manner that they will not come in contact with each other if their containers are broken. Chemicals should be divided into proper reactivity categories (such as acids and bases) for storage.
- Secondary containment should be provided, and is required, for some hazardous liquid materials. One method used to provide secondary containment is the use of plastic tubs or basins. They can also provide chemical isolation by separating incompatible chemicals from one another. Contact your local ES&H Team for guidance.
- Secondary containment such as dikes, berms, or basins may be required to contain spills around equipment or storage areas in which hazardous materials are stored or used. Some tank and piping systems may also require a means of secondary containment. Contact your local ES&H Team for guidance.
- Consider providing a drainage system, within a laboratory space or for outside areas, to collect spilled liquids in a holding basin rather than allowing them to flow into the sanitary or storm water sewer systems.
- Larger and heavier containers containing hazardous materials should be stored on the lowest shelves available to minimize their motion during an earthquake.
- Open shelves containing hazardous materials in breakable containers shall be equipped with earthquake strips, lips, rods, wires, or other devices to prevent the containers from falling off shelves.

- Cabinets and lockers containing hazardous materials shall be equipped with sliding doors or positive locking latches on swinging doors (no magnetic latches are permitted). Shelves with glass doors (except for the wired type) shall be equipped with earthquake strips or lips.
- Open vessels, vats, dip tanks, and similar items that contain hazardous liquids shall be secured so that they will not turn over, and shall be designed to reduce spillage due to sloshing.
- Glove boxes shall be secured against falling over, sliding, or rolling.
- Compressed gas cylinders shall be adequately secured when in storage or in service in accordance with the requirements of Document 18.1, "Pressure," and Document 14.3, "Toxic, Corrosive, or Reactive Gases," in the *ES&H Manual*.
- Toxic, corrosive, or reactive gases shall be stored or used in accordance with the requirements of Document 18.1 and Document 14.3. Toxic gas cabinets or other vented enclosures are required. Seismic shut off valves and other controls are required for the use and storage of these gases. Toxic gas cabinets or enclosures must be seismically secured to prevent them from tipping over during an emergency.

7.3 Machinery (Woodworking, Metalworking, Data Processing, Duplicating, etc.)

- Shop machines that are normally in a fixed location shall be secured to the shop floor or to a bench.
- Portable machines shall be secured against movement except when actually being moved. Chocks, chains, lockable wheels, or other means shall be used. If the center of gravity is above the midpoint of the machine, the machine shall also be secured against overturning or sliding, using appropriate engineering design and calculations.

7.4 Ceilings and Light Fixtures

All ceilings and light fixtures at LLNL, at a minimum, shall be designed in accordance with Plant Engineering's standards for suspended ceiling systems, as set forth in LLNL Facilities Specifications (available from the Plant Engineering Standards and Documentation Group). In addition, the following requirements shall be incorporated:

- All hooks used to hang lighting fixtures shall have safety latches and shall be closed completely or secured by an approved method.

- Lighting fixtures supported by flexible hangers shall be located so that they will not collide with other building elements.
- Grills, diffusers, and lenses shall be permanently fastened to the fixture or provided with safety chains.

7.5 Computer Floors

Computer and other raised floors shall be braced for the intended loads, including seismic loading. Refer to LLNL Facilities Specifications (available from the Plant Engineering Standards and Documentation Group). Special attention is needed for equipment resting on raised floors. Often, floor panels are not secured to their supports. Do not anchor equipment to floor panels alone.

7.6 Mechanical Systems

All mechanical systems at LLNL are required to meet nationally approved and recognized design codes and standards. In addition, they shall be designed to withstand seismic loading.

All new installations, and existing installations in critical and major program areas, shall meet the following criteria:

- Supports for tanks and heavy equipment shall be designed to withstand earthquake forces and shall be anchored to the floor or otherwise secured.
- Suspended tanks shall be strapped to their hanger system and provided with lateral bracing.
- All suspended equipment shall have lateral bracing. If suspended equipment is allowed to move, damping elements or restraints shall be built into the hanger system to restrict the amount of movement.
- All chimneys and masonry stacks shall be of earthquake-resistant design.
- Domestic hot-water heaters shall be provided with legs that can withstand earthquake forces, and they shall be anchored to the floor or strapped to a structurally sound wall.
- Earthquake-sensitive shut-off valves on natural gas service lines shall be provided at the main service entrances to buildings.

In addition, the following criteria should be considered when designing a mechanical system (alternative designs that provide equivalent earthquake safety are acceptable):

- Flexible piping connections should be used between tanks and piping headers where possible.
- Where practicable, pipelines should be tied to only one structural system. Where structural systems change, and relative deflections are anticipated, the pipeline should be designed to account for movements of the structural system.
- Suspended piping systems should have consistent freedom throughout; for example, branch lines shall not be anchored to structural elements if the main line is allowed to sway.
- If the piping system is allowed to sway, movable joints should be installed at equipment connections.
- Pipelines leading to thermal-expansion loops or flexible pipe connections should be guided to confine the degree of pipe movement.
- Long hangers and supports for ductwork should be provided with lateral bracing.
- Flexible duct connections should be installed in a semifolded condition, with enough material to allow for the expected differential movement between fans and ductwork.
- Pipelines installed in diked or bermed areas should not be routed to pass through the walls of the dike or berm. Rather, they should be installed over the top edge of the dike or berm to avoid possible underground rupture of the pipeline or damage to the dike or berm itself.

7.7 Electrical Equipment

All new equipment, and existing equipment servicing vital program and emergency needs, shall meet the following criteria (alternative designs that provide equivalent earthquake safety are acceptable):

- All electrical equipment such as transformers, switchgear, switchboards, control panels, and battery racks (or enclosures) shall be anchored.
- Flexible braided connections shall be used in place of rigid copper bus whenever relative movements can occur between switchboard components.
- Where conduits and bus ducts need to cross seismic joints, the crossing shall be made at the lowest floor possible, and shall be designed to protect against damage from seismic movement.

In addition, the following criteria should be considered when designing an electrical system (alternative designs that provide equivalent earthquake safety are acceptable):

- Separate ground conductors should be provided in all conduit runs that cross seismic joints, and elsewhere in the electrical system where grounding systems could be broken.
- Additional pull boxes with slack conductors should be provided in long conduit runs to avoid tensioning of conductors.
- Starters for motors subject to damage by low-service voltages after an earthquake should be provided with under-voltage relays.

7.8 Emergency or Standby Power and Lighting

- Emergency-power generators and all of their supporting components shall be tied down, and where vibration isolation needs to be provided, the floor mounts and connecting piping shall be provided with horizontal restraints.
- Self-contained generators shall be used wherever possible to reduce potential damage to fuel, cooling-water, and exhaust lines. Lines should be kept as short as possible.
- Fuel tanks shall not be located closer than 20 feet from the generator. When they need to be remote, then day tanks shall be provided on the generator or on an adjacent wall. Day tanks shall be large enough to provide fuel to operate the generator for several hours, and shall be equipped with alarm devices to indicate loss of, or low level of, line pressure and low fuel level. Powered fuel-oil pumps should be backed up with hand pumps.
- Small copper fuel-gauge lines from the tank to the engine room shall be protected from damage by a second pipe or conduit; larger lines with thick walls may not require this protection. Where they pass through walls, all fuel lines shall be protected by sleeves.
- All emergency generators that operate on natural gas shall have carburetors that can switch to diesel oil or other fuel in the event of low gas pressure.
- Battery-powered emergency lighting units shall be securely tied to the building.
- All batteries in racks shall be securely strapped or otherwise restrained to prevent movement, and the racks shall be designed to withstand earthquakes.

7.9 Optical and Granite Tables

Heavy optical and granite tables, such as those used for laser operations or precision alignment or assembly, shall have seismic restraints in the form of snubbers and vibration isolators when vibration isolation is a programmatic requirement. Seismic bracing and/or anchorage are required for all other applications. This is a Laboratory requirement and exemption may be granted with the concurrence of the ES&H Team and the approval of the authorizing individual.

8.0 Educational and Training Programs for Seismic Safety

The Hazards Control Safety, Education and Training Section develops, promotes, and presents training programs for all LLNL workers. The purpose of the training programs is to clarify the responsibilities of all workers and ensure proper action before, during, and after a serious earthquake, both at work and at home. Methods for reducing seismic hazards and performing preventive maintenance are presented. Contact the Safety, Education and Training Division of the Hazards Control Department for registration information regarding current training programs.

9.0 Responsibilities

General responsibilities for all Laboratory workers can be found in Document 2.1, "Laboratory and ES&H Policies, General Worker Responsibilities, and Integrated Safety Management," in the *ES&H Manual*. Specific responsibilities for earthquakes are listed below.

9.1 Workers

- Follow the seismic safety requirements of the Laboratory.
- Review and monitor their work and work areas for the potential for seismic hazards.
- Report seismic concerns to their supervisors or to their local environment, safety, and health (ES&H) Team.
- Take necessary steps, as outlined in this document, to protect themselves from injury during and following an earthquake.

9.2 Responsible Individuals

- Plan for earthquakes in their activities.
- Review their work areas and experiments for seismic hazards and ensure that such concerns are adequately addressed.

The responsibility for implementing the seismic safety program at LLNL is held jointly by Plant Engineering, Mechanical Engineering, the Hazards Control Department, the Earth and Environmental Sciences Directorate, and the Emergency Preparedness and Response Program.

9.3 Plant Engineering Department

- Establish and implement seismic design criteria for the design or upgrade of facilities. Four separate performance categories (PCs) have been established as criteria for seismic design or upgrade of buildings (PC-1, PC-2, PC-3, and PC-4). A detailed description of the seismic design criteria associated with each PC can be found in DOE-STD-1020-94. The determination of which level to use is evaluated jointly and on a case-by-case basis by Plant Engineering, the Hazards Control Safety Analysis Group, the Safety Team leader, and the program concerned.
- Assemble and maintain an Emergency Facilities Engineering Support Team. The function of this team is to provide structural inspection and utilities engineering support before, during, and after a disaster.

9.4 Mechanical Engineering Department

- Evaluate the seismic resistance of programmatic equipment and experimental apparatus in response to programmatic needs. Guidance on seismic requirements and their application to equipment and apparatus can be found in the Mechanical Engineering Department *ME Design Safety Standards Manual*.
- Provide seismic and structural analyses, evaluations, walkdown inspections, and consultations to Plant Engineering and the Hazards Control Department through the HMC, as required.

9.5 Hazards Control Department

- Provide safety guidance and hazards evaluations for LLNL seismic safety.
- Provide safety criteria for seismic corrections, and surveillance where modifications are being made in hazardous areas. Determination of the

seismic design level is made by the Safety Analysis Group with concurrence of the Safety Team leader.

- Conduct routine inspections of all buildings and facilities, which includes identifying seismic hazards, requesting appropriate corrective action, and following up to ensure that adequate corrective action has been taken.
- Conduct earthquake-preparedness training for workers and management.
- Provide guidance and assistance in preparing Self-Help Plans [see Document 22.1.].

9.6 Earth and Environmental Sciences Directorate

- Maintain the strong motion network, which includes instrumentation to measure strong ground motion that could occur during an earthquake on the LLNL site. The network is described in *Earthquake Strong-Motion Instrumentation at Lawrence Livermore National Laboratory* (UCRL-53246).
- Monitor background motion to identify unknown sources of seismicity. Monitoring is accomplished by maintaining the Local Livermore Seismic Network, which consists of 28 remote recording stations established throughout the Livermore Valley in cooperation with personnel in the Earth Sciences Department of the U.S. Geological Survey in Menlo Park, CA.
- Maintain seismic triggers that automatically turn off equipment, such as gas lines, during an earthquake.
- Provide information on strong motion data to Laboratory management immediately following a major earthquake to assist in their emergency response efforts. A few days later, they provide an analysis of accelerometer data to assist in structural analysis and damage assessment efforts.

10.0 Work Smart Standards

8 CCR Subchapter 6, "Elevator Safety Orders."

10 CFR 830, “Nuclear Safety Management,” including Subpart A, Quality Assurance Requirements (830.120 - 830.122) and Subpart B, Safety Basis Requirements (830.200 - 830.207).

DOE O 420.1 Chg. 3, Facility Safety, Attachment 2, Contractor Requirements Document, Paragraph 4 except 4.1.2, 4.1.3, and excluding the invocation of ANS 8.9, ANS 8.10, and ANS 8.17 and other references to explosives safety.

DOE Order 430.1A, Chg 1, "Life Cycle Asset Management."

DOE-STD-1020-02 (CH-1), "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities."

DOE-STD-1021-93 (CH-1), "Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components."

DOE-STD-1022-94 (CH-1), "Natural Phenomena Hazards Characterization Criteria."

DOE-STD-1023-95 (CH-1), "Natural Phenomena Hazards Assessment Criteria."

DOE-STD-1027-92 (CH-1), "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE O 5480.23," Sections 2, 3, 4, and Attachment 1 (except for the requirement for Certificates of Compliance for Type B containers).

Uniform Building Code (UBC), 1997, with exception of Chapters 1, 3, 4, 8, 9, and 10.

11.0 Resources for More Information

11.1 Contacts

For more information, please contact the ES&H Team for your area; the Mechanical Engineering Department; the Plant Engineering Design and Construction Division Office; or the Hazards Mitigation Center (HMC). The HMC can be visited at the following Internet address:

http://www-ep.es.llnl.gov/www-ep/ghp.html

11.2 Applicable Lessons Learned

Refer to the following Internet address for lessons learned applicable to the topic of earthquake safety:

http://www-r.llnl.gov/llnl_only/es_and_h/lessons/lessons.shtml

11.3 Executive Orders

Executive Order, EO 12699, "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction" (January 5, 1990).

Executive Order, EO 12941, "Seismic Safety of Existing Federally Owned or Leased Buildings" (December 1, 1994).

11.4 LLNL Standards

LLNL Mechanical Engineering Department, *ME Design Safety Standards Manual*, Section 5.2, "Seismic and Wind Design Criteria," Lawrence Livermore National Laboratory, Livermore, CA (1993).

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